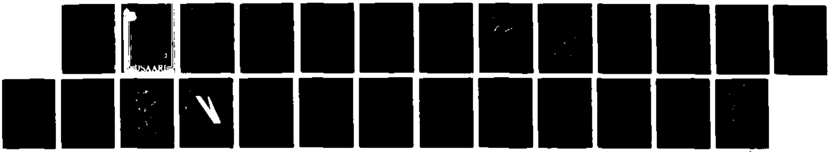
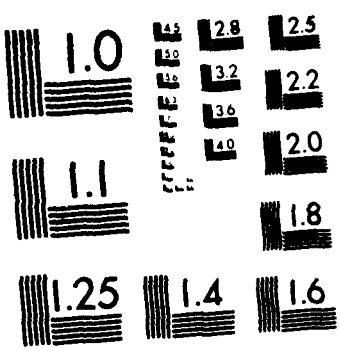
AD-A192 017 IMPROVED DESIGN CRITERIA FOR CRASH HELMETS(U) ARMY AEROMEDICAL RESEARCH LAB FORT RUCKER AL R F ROLSTEN ET AL. MAY 86 USAARL-86-11 1/1

UNCLASSIFIED F/G 23/4 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

AD-A192 017

DTIC FILE COPY

USAARL REPORT NO. 86-11

IMPROVED DESIGN CRITERIA FOR CRASH HELMETS

By

R. Fred Rolsten

J. Haley, Jr.

BIODYNAMICS RESEARCH DIVISION

May 1986

USAARL

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: USAARL Report No. 86-11	2. GOVT ACCESSION NO.: ADA192017
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Improved Design Criteria for Crash Helmets	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): R. Fred Rolsten and Joseph L. Haley, Jr.	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Biodynamics Research Division, SGRD-UAD US Army Aeromedical Research Laboratory Box 577, Fort Rucker, AL 36362-5000	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62777A 3E162777A878 AG 138
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: May 1986
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES Presented at the Second Southern Biomedical Engineering Conference held in San Antonio, Texas, September 1983. Published in Biomedical Engineering II, Recent Developments, Proceedings of the Second Southern Biomedical Engineering Conference, New York, Pergamon Press, 1983, pp. 205-208.
(See Reverse Side of this form)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Helmets, Helmet Impact Testing, Head Impact Tolerance

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See Back of Page

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

i

18. Portions of this presentation are included in USAARL Report No. 85-5, Dynamics of Head Protection (Impact Protective Comparison of the SPH-4 Flight Helmet to a Commercial Motorcycle Helmet, by R. Fred Rolston and J. L. Haley, Jr. July 1985.

20. A commercial motorcycle helmet was impact evaluated. The motorcycle helmet's impact protection is compared to that of the SPH-4, the standard Army aviator's helmet. Drop tests, ranging from 0.91- to 2.44-meters, were used for the helmet testing by means of a helmet/headform free-fall device. The two examples of the helmet were subjected to 16 drop tests. Two of these drop tests resulted in a high level of transmitted force and acceleration which focuses on the inadequate thickness of the motorcycle helmet liner. The helmets did not provide adequate protection to prevent concussion or serious injury at all energy levels greater than produced at a 1-meter drop height. The tested helmets could be changed to provide adequate protection by doubling the thickness of the liner.

Table of contents

List of figures

List of tables

Introduction

Based on government motorcycle test standards in this country and abroad, your head may sustain a transmitted deceleration of up to 400 g as a result of impacting pavement from a six-foot fall. Various studies since 1962 have shown that g levels above 150 will result in various degrees of injury. Levels about 250 g could be fatal based on the studies of knockout boxing impacts; thus, it is imperative that helmet design/test criteria be revised.

It is well within industry capability to construct improved impact protective helmets; however, the compressive foam must be reduced in density and increased in thickness and the test impact surface must be changed to a flat rather than a sharp corner surface.

This report illustrates the performance of two foreign motorcycle helmets and shows the improvement possible by reducing foam density and increasing its thickness.

Method

The commercial motorcycle helmet shown in Figure 1, was impact evaluated. The shell was a solid integral-white plastic of 4.2 mm thickness at the crown, with a thickness of 3.5 mm in the hatband region. The polystyrene energy-absorbing liner of 12 mm thickness was located about 3 cm above the ear canal at the sides and about 2 cm below the occipital bone at the rear. Retention of the helmet was accomplished by the chin strap, which was yoke-mounted to the shell. The yoke mount is preferable to a single swivel mount to the shell because rotation either forward or rearward is more difficult.

Procedure

The impact tests were conducted on a drop tower conforming to or exceeding American Standards Association (ASA) Z90.1-1971 standards; the impact test device is shown in Figure 2. The rigid base plate exceeds Z90.1 requirements by an order of magnitude; i.e., it weighs over 1800 kg. This mass insures that the headform acceleration is as accurate as is feasible at high acceleration levels. The helmeted headform was impacted primarily on a flat surface, but three impacts were conducted on the standard Z90.1 (4.8 cm radius hemisphere) impact surface to provide comparative data. The helmets were placed on a medium size (3.76 kg) cast magnesium headform with one accelerometer mounted near the center of gravity as shown in Figure 2. The magnesium headform was attached to a lightweight cage and the cage was guided vertically on two steel cables. The headform,

helmet, and cage were elevated up the vertical cables to a selected drop height for each impact test. The weight of the headform and cage was 11.0 lb (5.0 kg) while the weight of the helmet was 2.9 lb (1.3 kg) for a total drop weight of 13.9 lb (6.3 kg).

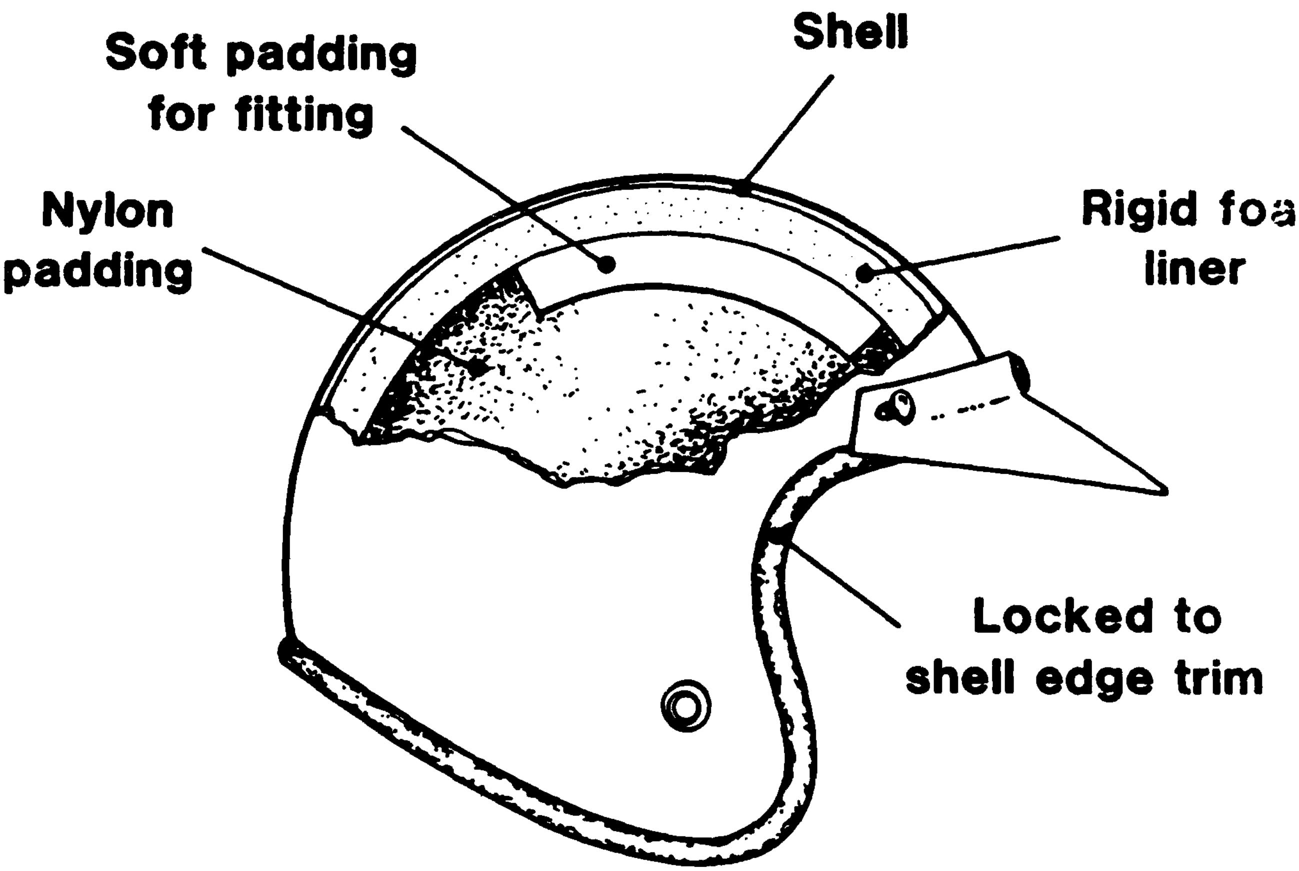


Figure 1. Cutaway view of the motorcycle test helmet.

A uni-axial accelerometer was positioned near the headform's center-of-mass, and its signal was amplified by a signal conditioner. Three piezoelectric load washers (Kistler type 9021) were positioned beneath the force plate shown in Figure 2. The accelerometer and force plate transducer were displayed on an oscilloscope and also read from peak voltage meters.

The test sequence and impact locations for the motorcycle helmet are shown in Table 1. The drop sequence is shown by test number in the table. The drop height was varied from 0.91- to 2.44-m.

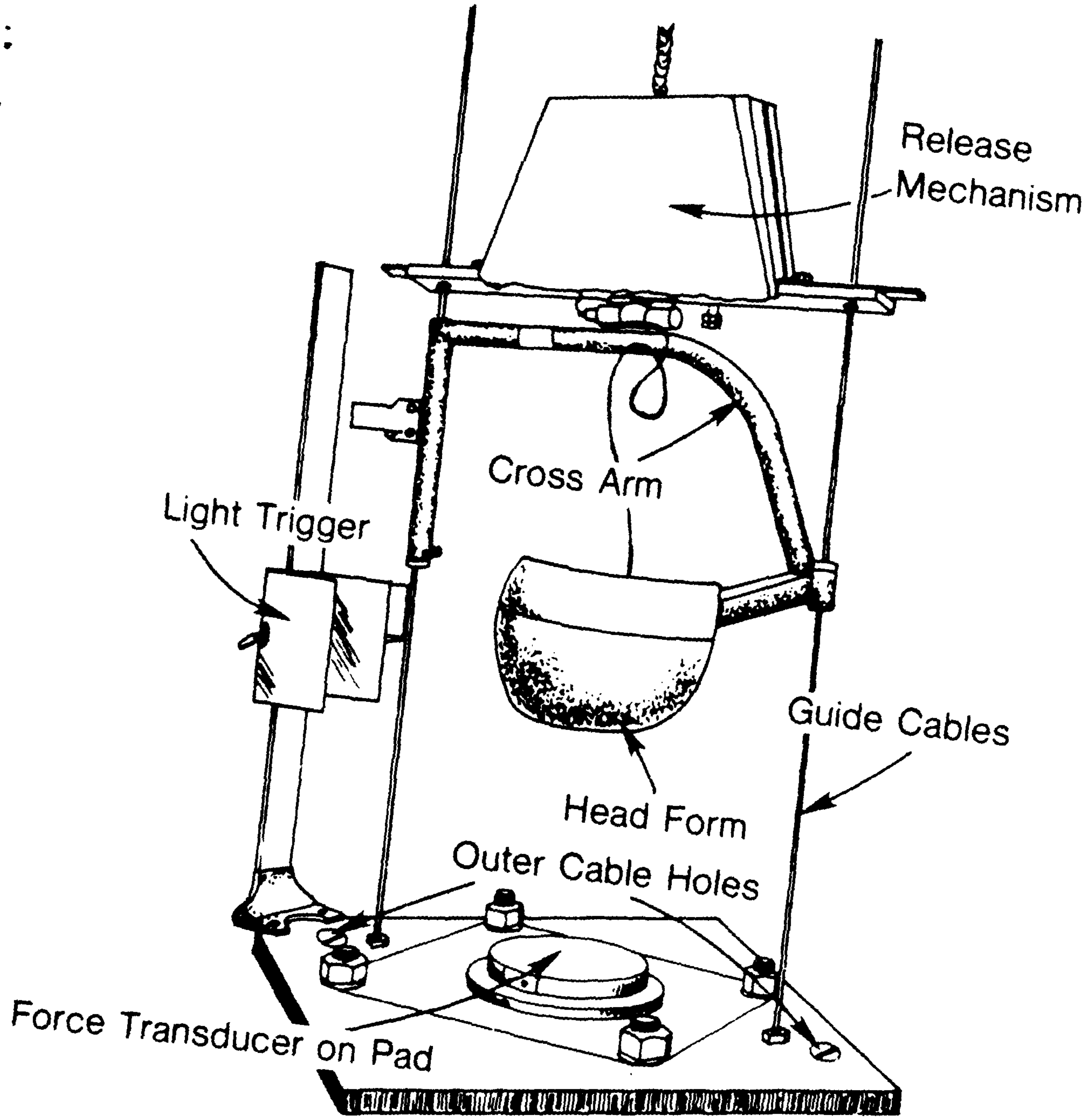
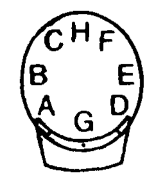


Figure 2. Helmet/headform free-fall test device.

Table 1. Peak G, transmitted force, and rebound velocity measured in 16 helmet-headform impacts.

HELMET NO.	DROP NO.	DROP LOCATION	IMPACT SURFACE	OFFSET(a) DIST. (cm)	DROP(b) HEIGHT (meters)	MEASURED(c) FORCE (NEWTONS)	DECELERATION Calc.(d) PEAK (G)	DECELERATION MEASURED PEAK (G)	DECELERATION Calc.(e) Avg. (G)	PULSE DURATION (millisec)	REBOUND VELOCITY (m/sec)
1	10A	R FRT	FLAT	2.5	1.47	12,090	244	249	92.5	8.0	.58
1	13B	R SIDE	FLAT	2.5	1.47	13,890	279	258	105.9	7.7	.82
1	14C	R REAR	FLAT	2.2	1.47	14,810	298	287	113.7	6.6	.64
1	22D	L FRT	FLAT	2.1	2.44	19.620	394	402	117.4	8.0	.73
1	23E	L SIDE	FLAT	2.5	2.44	18,740	377	350	135.8	7.6	.98
1	24F	L REAR	FLAT	2.1	2.44	30,030	604	576	154.4	6.0	.67
1	25G	CTR FRT	FLAT	1.9	2.13	22,300	448	430	135.0	6.6	.82
1	26H	CTR REAR	FLAT	2.5	2.13	19,620	394	382	147.6	6.7	1.1
2	11A	R FRT	4.8cm rad. Hemisphere	1.4	1.47	16,850	339	353	132.4	5.4	.52
2	12B	R SIDE	"	2.7	1.47	10,170	204	196	82.2	10.0	.70
2	16C	R REAR	"	3.3	1.47	17,090	344	330	90.8	7.7	.58
2	17D	L FRT	FLAT	2.4	0.91	9,410	189	195	79.0	7.8	.61
2	18E	L SIDE	FLAT	2.5	0.91	10,070	202	174	83.5	7.6	.61
2	19F	L REAR	FLAT	2.1	0.91	10,470	211	176	83.9	7.2	.55
2	20H	REAR CTR	FLAT	2.1	1.22	13,930	280	252	108.8	6.3	.64
2	21G	FRT CTR	FLAT	2.5	1.22	13,270	267	237	98.2	7.5	.79

(a) Distance from shell outer surface to the metal headform
(b) Vertical distance from the impact surface to helmet's point of contact
(c) Reaction force in load cell at the impact surface
(d) This value is calculated as follows: $G = \frac{f \times 10^3}{9.81 \times m}$ where f = Transmitted force in Newtons and m = mass of headform and guide cage of 5070 grams
(e) This value is calculated as follows: $G_{avg} = \frac{\text{area under (accel x time) trace}}{\text{total pulse duration}} = \frac{\Delta V}{t}$



Front of Helmet

Results and discussion

The two motorcycle-type helmets were subjected to 16 impact tests. The location of impact, energy of impact (drop height and total drop mass), impact surface, transmitted force, and acceleration to the headform are presented in Table 1. The centroid of all impact points was at least 6 cm above the lower edge of the foam liner. The effect of increased drop height and concomitant impact energy from 0.91 to 1.47 m is shown in the plot of acceleration vs. time in Figure 3. The difference between a flat surface and a 4.8 cm radiused surface for equal impact energy (1.47 m drop height) also is shown in Figure 3. It should be observed that the acceleration value obtained for eight (Nos. 10, 13, 14, 17, 18, 19, 20, and 21) impact tests at three different drop heights (0.91-, 1.22-, and 1.47 m) are consistent. This indicates uniform quality of the helmets as well as good instrumentation. The significant variation of the traces in the 4.8-cm radius drops shown in Figure 3 probably are caused by friction between the guide cables and the headform guide cage. This type of problem is more likely to occur when impacting the radiused surface than when impacting a flat surface due to the lateral movement of the headform and guide cage, as the helmet tends to "slip or slide" down the side of the radiused surface. The effect of increasing the drop height to 2.13- and to 2.44-m is shown in Figure 4. At the 2.13-m drop height, the two traces nearly are identical. At the 2.44-m drop height, the three traces differ as evidenced from comparison of the 580 peak _g_ on run 24 F (left rear) and the 350 peak _g_ on run 23 E (left side). This large difference in peak _g_ response most likely is caused by the "bottoming out" of the foam liner in run 24 F due to the small volume of foam compressed. A difference of only 1 mm in crush distance can result in a significantly large change in the peak acceleration level. It is possible that the friction prevented drops 22 D and 23 E from being greater than shown in Figure 4.

Peak headform deceleration vs. drop height is shown in Figure 5 and can be compared to the derived WSU tolerance curve (Haley _et al._ 1966); the effect of various energy levels is shown. The derived curve reveals (with three exceptions) that all experimental impacts on these helmets resulted in injurious _g_ values.

The 1975 Snell Foundation Helmet Specification calls for the helmet to permit transmission of a peak acceleration of 300 _g_ or less when dropped from a height of 3.3 m (10.83 ft). From Figure 5, it can be seen that 9 out of the 16 experimental drops (Nos. 10, 12, 13, 14, 17, 18, 19, 20, and 21) would have passed the Snell Specification while the experimental runs designated Nos. 11, 16, 22, 23, 24, 25, and 26 would not have passed.

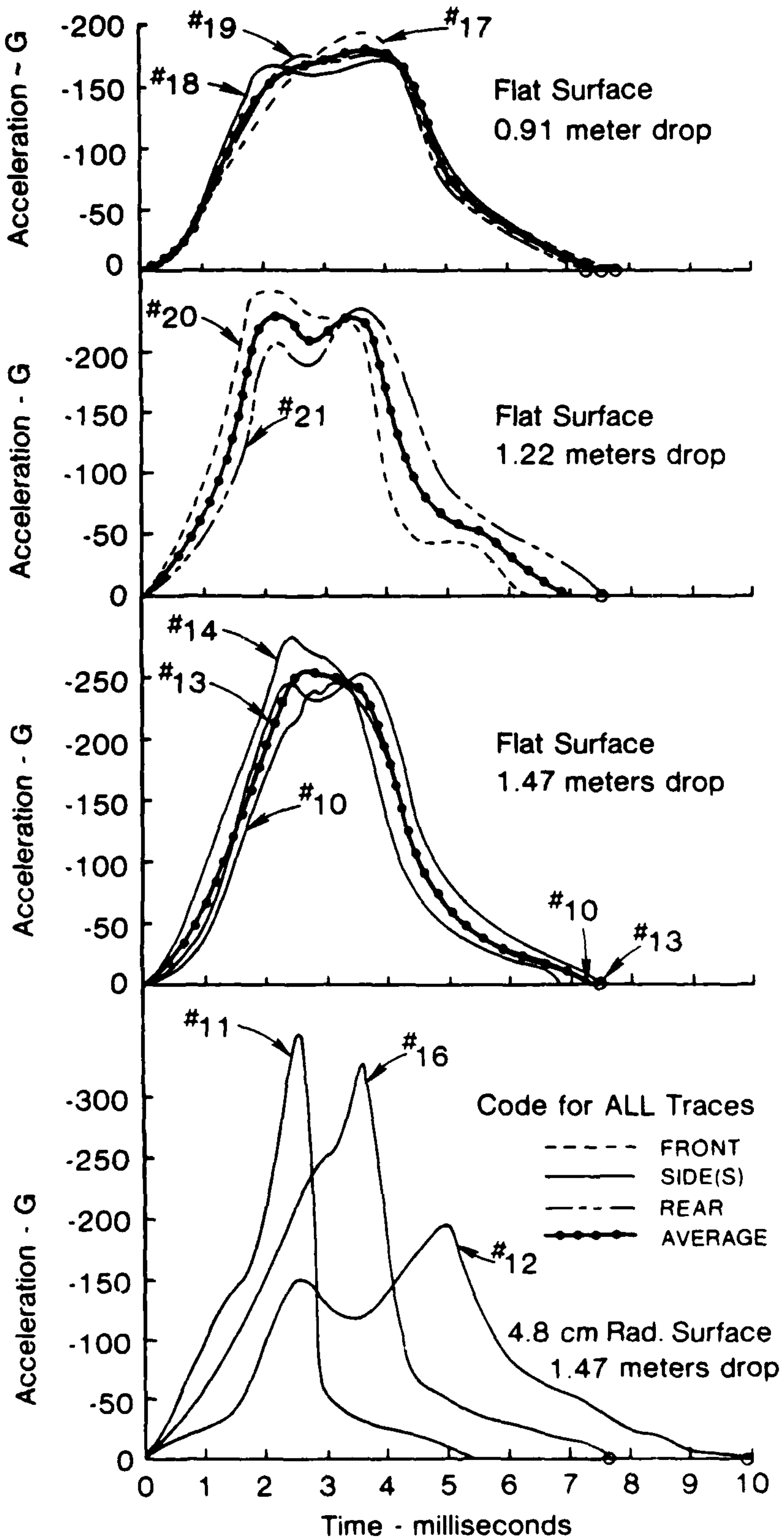


Figure 3. Variation of transmitted accelerations for three drop heights.

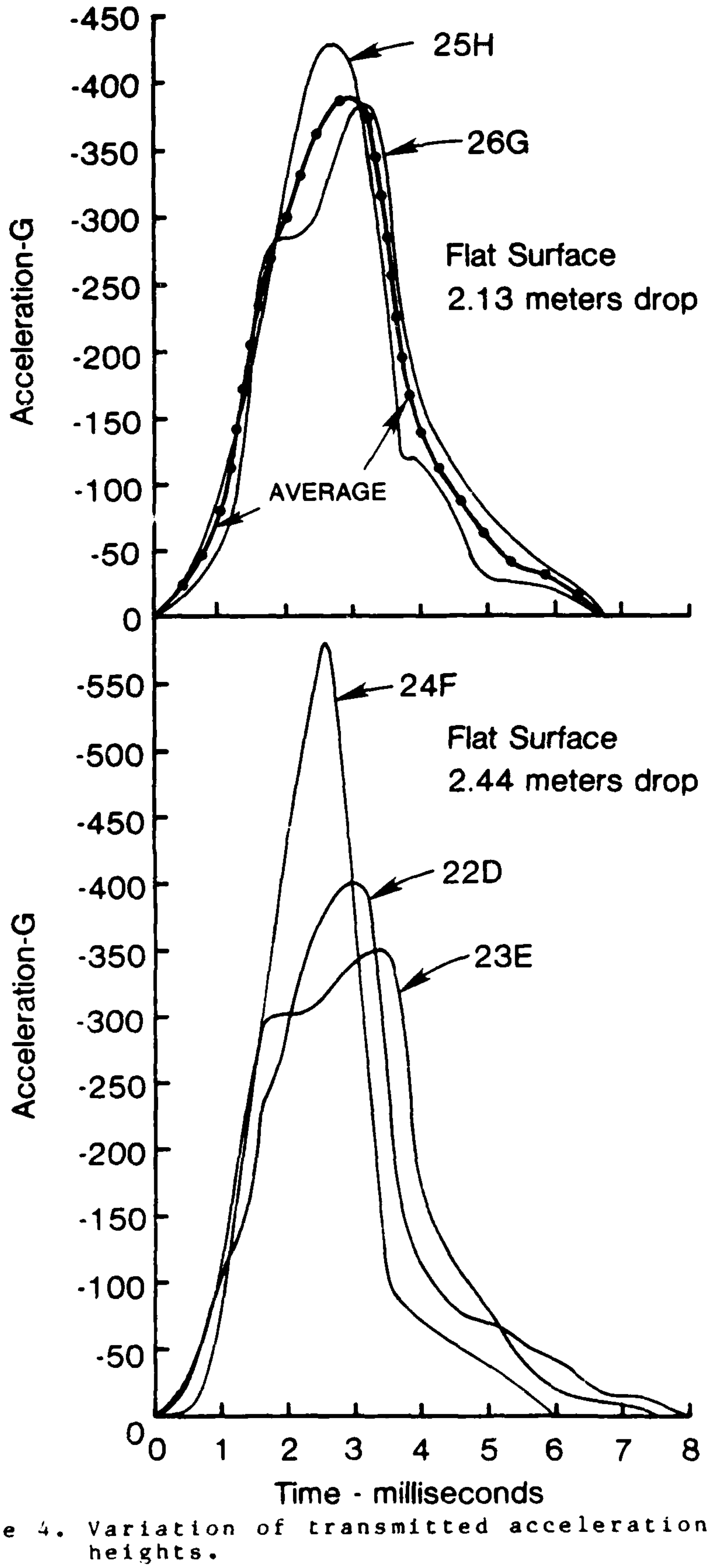


Figure 4. Variation of transmitted accelerations for two drop heights.

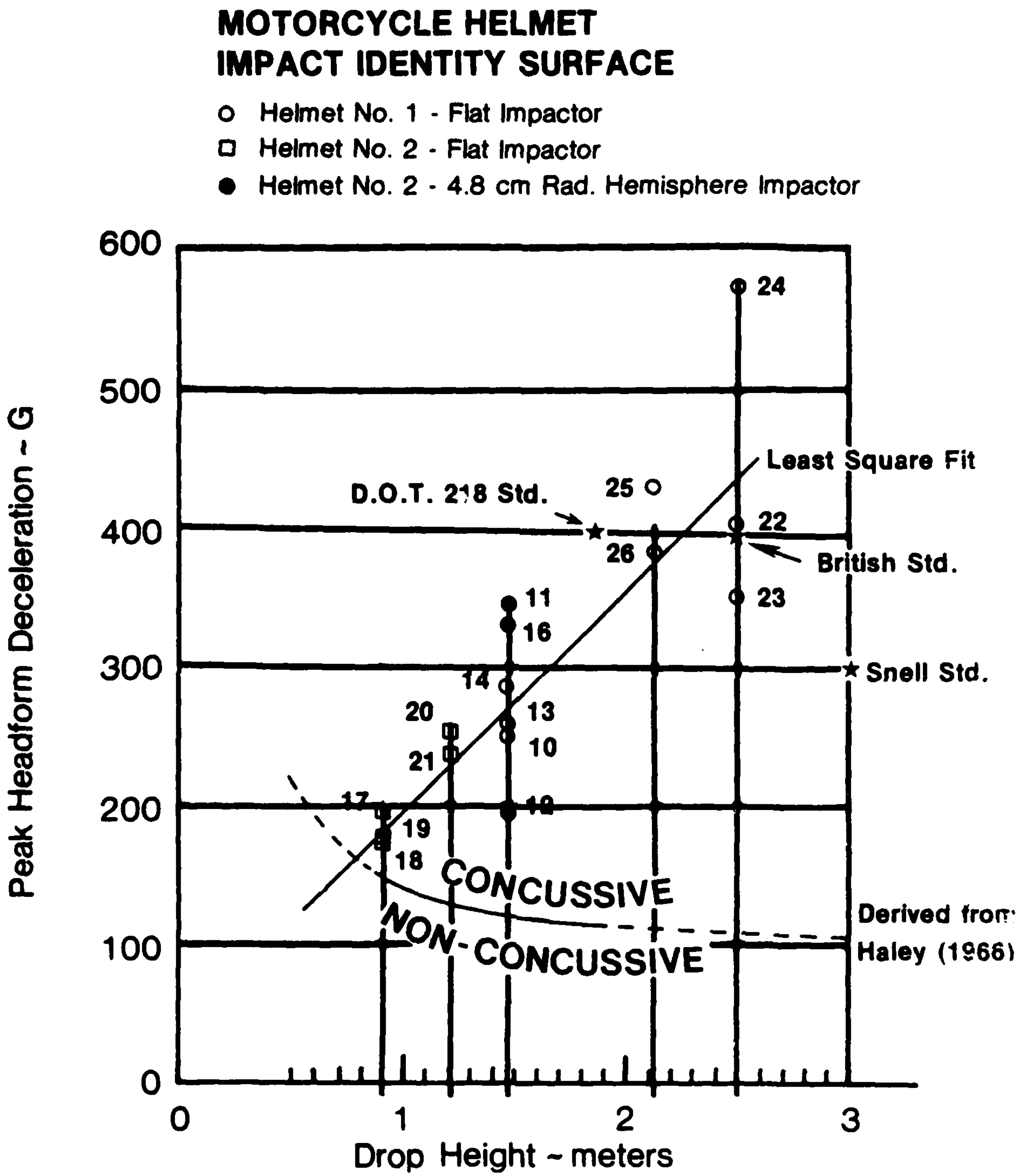


Figure 5. Peak headform deceleration vs. drop height compared to derived Wayne State University tolerance curve.

The British Standard requires that a motorcycle helmet not cause a peak headform force of greater than 4,400 lb (19,580 N) when a 5 kg headform mass is dropped from a height of 2.5 m (8.20 ft). From Table 1, it can be seen that experimental drops 24 and 25 resulted in a transmitted force of 30,000 N (6,673 lb) and 22,300 N (4,955 lb), respectively, and would have failed the requirements of the British (2001) Standard, as well as the US Department of Transportation (DOT) 218 Standard and the 1975 Snell Foundation Standard.

The fact that two of the impacts resulted in such a high level of transmitted force and acceleration focuses attention on the inadequate liner provided in the helmet. The liner should be no less than twice the thickness provided; *i.e.*, the liner should be no less than 25 mm in order to lower the transmitted force to tolerable levels for all impacts greater than 1 m in drop height.

Since it may be expected that motorcyclists may fall or be thrown from heights of 1.6 m up to 3.0 m, it is clear that riders could receive various degrees of head injury while wearing the helmet. These energy values are within the limits of 3.3 m (Snell 1975) and 1.8 m (DOT 218) for energy; however, both these standards permit transmitted acceleration to the head which is far in excess of the values recommended (Gurdjian 1962 and Haley *et al.*, 1966, 1983).

Compendium of US Army SPH-4 flight helmet testing

For comparative purposes, the transmitted deceleration of the standard US Army Flight Helmet (Figure 6), the Sound Protective Helmet No. 4 (SPH-4), for 3- through 6-ft drops is summarized in Figure 7. The thickness and density of the SPH-4 helmet was varied as shown in Figure 7 to determine the effect on transmitted peak *g*. It should be noted that the SPH-4 contains a polystyrene foam liner along with an energy-absorbing web suspension so that one would expect the helmet to yield lower peak *g* values, especially in the apex region than do other helmets with equal foam thickness.

Note in Figure 7 that doubling the thickness of the polystyrene foam liner of the SPH-4 can result in headform peak *g* values of only 140 *g* at a drop height of 6 ft. This would increase the weight by only one-tenth (0.1) lb. Such dramatic improvement clearly points the way to improved helmet design.

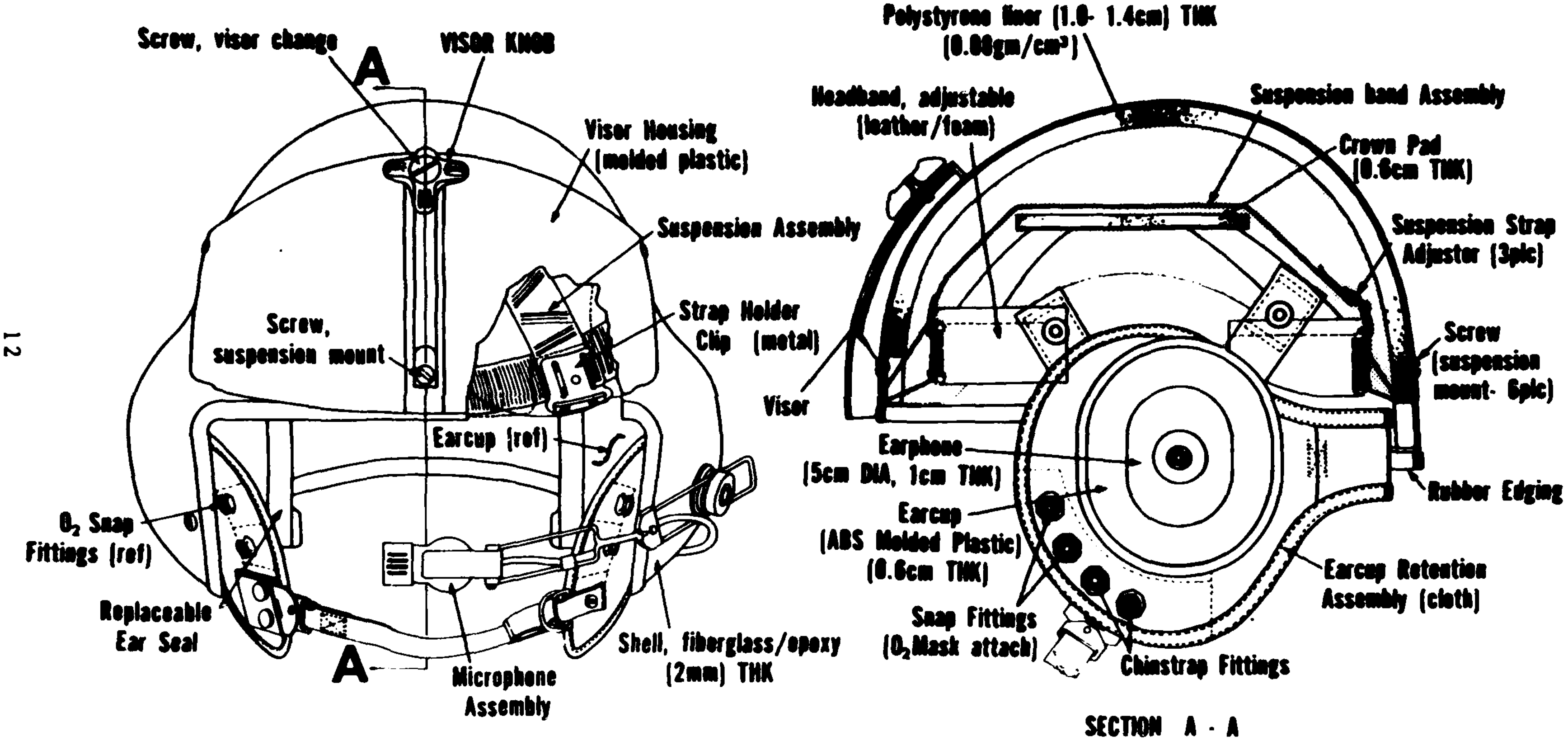


Figure 6. US Army aviator helmet--the SPH-4.

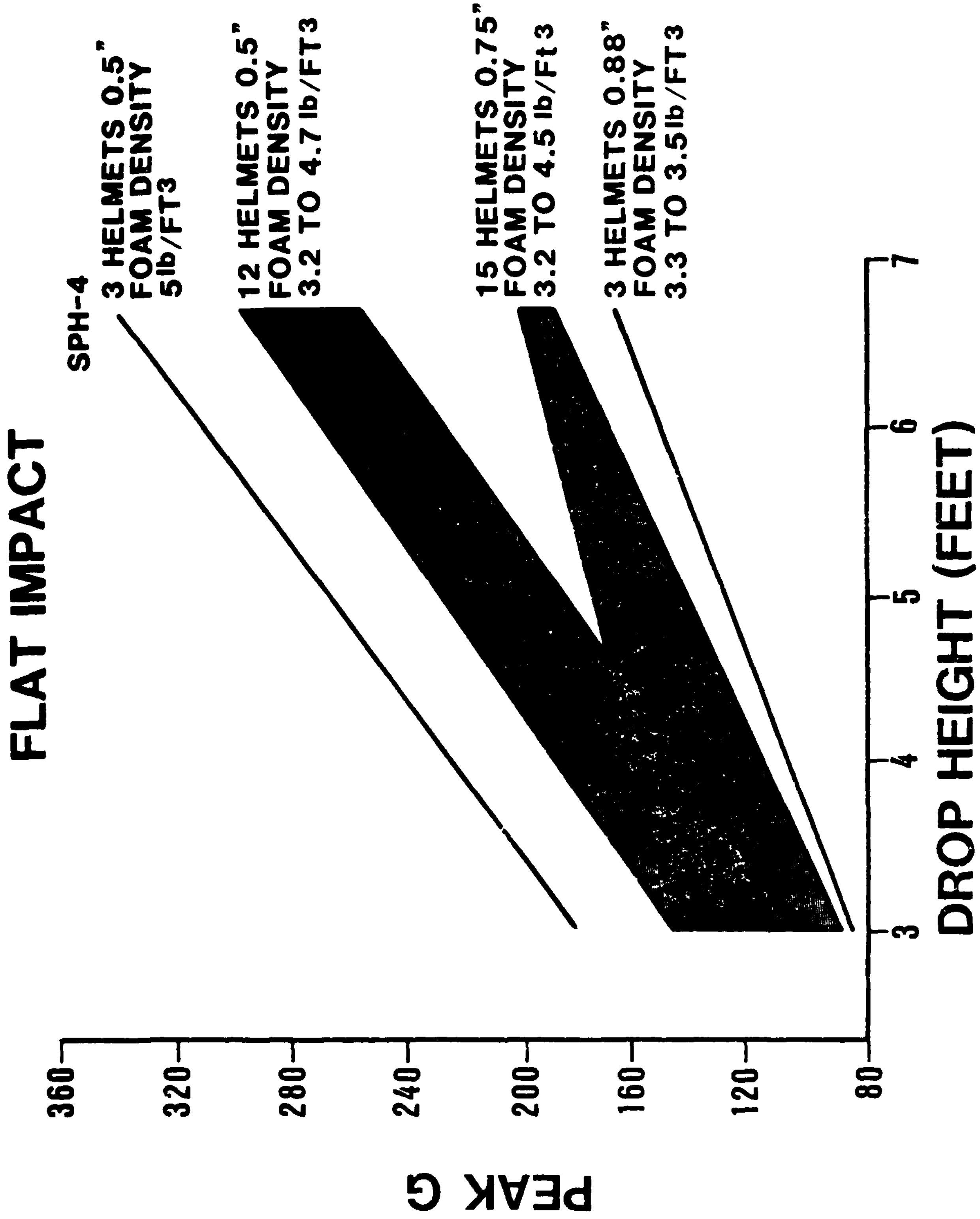


Figure 7. Transmitted deceleration of standard US Army aviator helmet (SPH-4).

Conclusions

1. The motorcycle helmets tested did not provide adequate force attenuation to prevent concussion and/or more serious injury at all energy levels greater that a 1-m drop height.

2. Existing helmet standards permit the production of helmets which provide less protection than is possible, practical, and feasible.

3. The motorcycle helmets tested could be changed to provide more adequate protection by the doubling of the liner thickness to approximately 2.5 cm.

References

American Standards Association (ASA). 1971. Specification for protective headgear for vehicular users. New York: American Standards Institute, Inc. Z90.1-1971.

British Standards Institution (BSI). 1972. British Standard 2001: 1972. London. British Standards Instution.

Federal Motor Vehicle Safety Standards and Regulations. 1974. (FMVSS-No 218)-Motorcycle Helmets. 1 March 1974.

Gurdjian, E. D., Lissner, H. R., and Patrick, L. M. 1962. Protection of the head and neck in sports. Journal of the Aerospace Medical Association. 182.(5): 509-514.

Haley, J. L., Jr., Turnbow, J. W., Macki, S., and Walhout, G. J. 1966. USAAVLABS TR 65-44 helmet design criteria for improved crash survival. Fort Eustis, VA. Department of the Army Aviation Material Laboratory, AD-628-678, 12-18.

Haley, J. L., Jr., Shanahan, D. F., Reading, T., and Knapp, S. 1983. Head impact hazards in helicopter operations and their mitigation through improved helmet design. In C. C. Thomas (Ed): Impact injuries of the head and spine. Chapter 18, p. 549.

Hundley, T. A., Haley, J. L., Jr., and Shanahan, D. F. 1981. Medical design criteria for US Army motorcycle helmet. Fort Rucker, AL: US Army Aeromedical Research Laboratory. USAARL LR-81-2-4-1.

Slobodnik, B. A. 1980. SPH-4 helmet damage and head injury correlation. Fort Rucker, AL: US Army Aeromedical Research Laboratory. USAARL Report No. 80-7.

Snell. 1975. Standard for protective headgear. Snell Memorial Foundation, Sacramento, CA.

INITIAL DISTRIBUTION

Commander
US Army Natick Research and
Development Center
ATTN: Documents Librarian
Natick, MA 01760

Commander
US Army Research Institute of
Environmental Medicine
Natick, MA 01760

Naval Submarine Medical Research
Laboratory
Medical Library, Naval Sub Base
Box 900
Groton, CT 05340

US Army Avionics Research and
Development Activity
ATTN: SAVAA-P-TP
Fort Monmouth, NJ 07703-5401

Commander/Director
US Army Combat Surveillance and
Target Acquisition Laboratory
ATTN: DELCS-D
Fort Monmouth, NJ 07703-5304

US Army Research and Development
Support Activity
Fort Monmouth, NJ 07703

Commander
10th Medical Laboratory
ATTN: Audiologist
APO New York 09180

Chief, Benet Weapons Laboratory
LCWSL, USA ARRADCOM
ATTN: DRDAR-LCB-TL
Watervliet Arsenal, NY 12189

Commander
Naval Air Development Center
Biophysics Lab (ATTN: G. Kydd)
Code 60B1
Warminster, PA 18974

Commander
Man-Machine Integration System
Code 602
Naval Air Development Center
Warminster, PA 18974

Naval Air Development Center
Technical Information Division
Technical Support Detachment
Warminster, PA 18974

Commander
Naval Air Development Center
ATTN: Code 6021 (Mr. Brindle)
Warminster, PA 18974

Dr. E. Hendler
Human Factors Applications, Inc.
295 West Street Road
Warminster, PA 18974

Commanding Officer
Naval Medical Research and
Development Command
National Naval Medical Center
Bethesda, MD 20014

Under Secretary of Defense for
Research and Engineering
ATTN: Military Assistant for
Medical and Life Sciences
Washington, DC 20301

Director
Army Audiology and Speech Center
Walter Reed Army Medical Center
Washington, DC 20307-5001

COL Franklin H. Top, Jr., MD
Walter Reed Army Institute
of Research
Washington, DC 20307-5100

Commander
US Army Institute of Dental Research
Walter Reed Army Medical Center
Washington, DC 20307-5300

HQ DA (DASG-PSP-O)
Washington, DC 20310

Naval Air Systems Command
Technical Library Air 950D
Rm 278, Jefferson Plaza II
Department of the Navy
Washington, DC 20361

Naval Research Laboratory Library
Code 1433
Washington, DC 20375

Naval Research Laboratory Library
Shock & Vibration Information Center
Code 5804
Washington, DC 20375

Harry Diamond Laboratories
ATTN: Tech Information Branch
2800 Powder Mill Road
Adelphi, MD 20783-1197

Director
US Army Human Engineering Laboratory
ATTN: Technical Library
Aberdeen Proving Ground, MD
21005-5001

US Army Materiel Systems
Analysis Agency
ATTN: Reports Processing
Aberdeen Proving Ground, MD
21005-5017

Commander
US Army Test & Evaluation Command
ATTN: AMSTE-AD-H
Aberdeen Proving Ground, MD
21005-5055

US Army Ordnance Center
& School Library
Bldg 3071
Aberdeen Proving Ground, MD
21005-5201

Director
US Army Ballistic Research Laboratory
ATTN: DRXBR-OD-ST Tech Reports
Aberdeen Proving Ground, MD
21005-5066

US Army Environmental Hygiene
Agency Library
Bldg E2100
Aberdeen Proving Ground, MD 21010

Commander
US Army Medical Research Institute
of Chemical Defense
ATTN: SGRD-UV-AO
Aberdeen Proving Ground, MD
21010-5425

Technical Library
Chemical Research & Development Center
Aberdeen Proving Ground, MD
21010-5423

Commander
US Army Medical Research
& Development Command
ATTN: SGRD-RMS (Mrs. Madigan)
Fort Detrick, Frederick, MD
21701-5012

Commander
US Army Medical Research Institute
of Infectious Diseases
Fort Detrick, Frederick, MD 21701

Commander
US Army Medical Bioengineering
Research & Development Laboratory
ATTN: SGRD-UBZ-I
Fort Detrick, Frederick, MD 21701

Dr. R. Newburgh
Director, Biological Sciences Division
Office of Naval Research
600 North Quincy Street
Arlington, VA 22217

Defense Technical Information Center
Cameron Station
Alexandria, VA 22314

Commander
US Army Materiel Command
ATTN: AMCDE-S (CPT Broadwater)
5001 Eisenhower Avenue
Alexandria, VA 22333

US Army Foreign Science and
Technology Center
ATTN: MTZ
220 7th Street, NE
Charlottesville, VA 22901-5396

Commandant
US Army Aviation Logistics School
ATTN: ATSQ-TDN
Fort Eustis, VA 23604

Director, Applied Technology Lab
USARTL-AVSCOM
ATTN: Library, Bldg 401
Fort Eustis, VA 23604

US Army Training and
Doctrine Command
ATTN: ATCD-ZX
Fort Monroe, VA 23651

US Army Training and
Doctrine Command
ATTN: Surgeon
Fort Monroe, VA 23651-5000

Structures Laboratory Library
USARTL-AVSCOM
NASA Langley Research Center
Mail Stop 266
Hampton, VA 23665

Aviation Medicine Clinic
TMC #22, SAAF
Fort Bragg, BC 28305

Naval Aerospace Medical
Institute Library
Bldg 1953, Code 102
Pensacola, FL 32508

US Air Force Armament Development
and Test Center
Eglin Air Force Base, FL 32542

Command Surgeon
US Central Command
MacDill AFB, FL 33608

US Army Missile Command
Redstone Scientific Information Center
ATTN: Documents Section
Redstone Arsenal, AL 35898-5241

Air University Library
(AUL/LSE)
Maxwell AFB, AL 36112

Commander
US Army Aeromedical Center
Fort Rucker, AL 36362

Commander
US Army Aviation Center & Fort Rucke
ATTN: ATZQ-CDR
Fort Rucker, AL 36362

Directorate of Combat Developments
Bldg 507
Fort Rucker, AL 36362

Directorate of Training Development
Bldg 502
Fort Rucker, AL 36362

Chief
Army Research Institute Field Unit
Fort Rucker, AL 36362

Chief
Human Engineering Labs Field Unit
Fort Rucker, AL 36362

Commander
US Army Safety Center
Fort Rucker, AL 36362

Commander
US Army Aviation Center & Fort Rucke
ATTN: ATZQ-T-ATL
Fort Rucker, AL 36362

US Army Aircraft Development
Test Activity
ATTN: STEBG-MP-QA
Cairns AAF, Ft Rucker, AL 36362

President
US Army Aviation Board
Cairns AAF, Ft Rucker, AL 36362

US Army Research & Technology
Laboratories (AVSCOM)
Propulsion Laboratory MS 302-2
NASA Lewis Research Center
Cleveland, OH 44135

AFAMRL/HEX
Wright-Patterson AFB, OH 45433

US Air Force Institute of Technology
(AFIT/LDEE)
Bldg 640, Area B
Wright-Patterson AFB, OH 45433

University of Michigan
NASA Center of Excellence
in Man-Systems Research
ATTN: R.G. Snyder, Director
Ann Arbor, MI 48109

Henry L. Taylor
Director, Institute of Aviation
Univ of Illinois - Willard Airport
Savoy, IL 61874

John A. Dellinger, MS, ATP
Univ of Illinois - Willard Airport
Savoy, IL 61874

Commander
US Army Aviation Systems Command
ATTN: DRSAV-WS
4300 Goodfellow Blvd
St Louis, MO 63120-1798

Project Officer
Aviation Life Support Equipment
ATTN: AMCPO-ALSE
4300 Goodfellow Blvd
St Louis, MO 63120-1798

Commander
US Army Aviation Systems Command
ATTN: SGRD-UAX-AL (MAJ Lacy)
Bldg 105, 4300 Goodfellow Blvd
St Louis, MO 63120

Commander
US Army Aviation Systems Command
ATTN: DRSAV-ED
4300 Goodfellow Blvd
St Louis, MO 63120

US Army Aviation Systems Command
Library & Info Center Branch
ATTN: DRSAV-DIL
4300 Goodfellow Blvd
St Louis, MO 63120

Commanding Officer
Naval Biodynamics Laboratory
P.O. Box 24907
New Orleans, LA 70189

Federal Aviation Administration
Civil Aeromedical Institute
CAMI Library AAC 64D1
P.O. Box 25082
Oklahoma City, OK 73125

US Army Field Artillery School
ATTN: Library
Snow Hall, Room 14
Fort Sill, OK 73503

Commander
US Army Academy of Health Sciences
ATTN: Library
Fort Sam Houston, TX 78234

Commander
US Army Health Services Command
ATTN: HSOP-SO
Fort Sam Houston, TX 78234-6000

Commander
US Army Institute of Surgical Research
ATTN: SGRD-USM (Jan Duke)
Fort Sam Houston, TX 78234-6200

Director of Professional Services
AFMSC/GSP
Brooks Air Force Base, TX 78235

US Air Force School
of Aerospace Medicine
Strughold Aeromedical Library
Documents Section, USAFSAM/TSK-4
Brooks Air Force Base, TX 78235

US Army Dugway Proving Ground
Technical Library
Bldg 5330
Dugway, UT 84022

Dr. Diane Damos
Department of Human Factors
ISSM, USC
Los Angeles, CA 90089-0021

US Army Yuma Proving Ground
Technical Library
Yuma, AZ 85364

US Army White Sands Missile Range
Technical Library Division
White Sands Missile Range, NM 88002

US Air Force Flight Test Center
Technical Library, Stop 238
Edwards Air Force Base, CA 93523

US Army Aviation Engineering
Flight Activity
ATTN: SAVTE-M (Tech Lib) Stop 217
Edwards AFB, CA 93523-5000

Commander
Code 3431
Naval Weapons Center
China Lake, CA 93555

US Army Combat Developments
Experimental Center
Technical Information Center
Bldg 2925
Fort Ord, CA 93941-5000

Aeromechanics Laboratory
US Army Research
& Technical Laboratories
Ames Research Center, M/S 215-1
Moffett Field, CA 94035

Commander
Letterman Army Institute of Research
ATTN: Medical Research Library
Presidio of San Francisco, CA 94129

Sixth US Army
ATTN: SMA
Presidio of San Francisco, CA 94129

Director
Naval Biosciences Laboratory
Naval Supply Center, Bldg 844
Oakland, CA 94625

Col G. Stebbing
USDAO-AMLO, US Embassy
Box 36
FPO New York 09510

Staff Officer, Aerospace Medicine
RAF Staff, British Embassy
3100 Massachusetts Avenue, NW
Washington, DC 20008

Canadian Society of Aviation Medicine
c/o Academy of Medicine, Toronto
ATTN: Ms. Carmen King
288 Bloor Street West
Toronto, Ontario M55 1V8

Canadian Airline Pilot's Association
MAJ J. Soutendam (Retired)
1300 Steeles Avenue East
Brampton, Ontario, L6T 1A2

Canadian Forces Medical Liaison Officer
Canadian Defence Liaison Staff
2450 Massachusetts Avenue, NW
Washington, DC 20008

Commanding Officer
404 Squadron CFB Greenwood
Greenwood, Nova Scotia BOP 1NO

Officer Commanding
School of Operational
& Aerospace Medicine
DCIEM, P.O. Box 2000
1133 Sheppard Avenue West
Downsview, Ontario M3M 3B9

National Defence Headquarters
101 Colonel By Drive
ATTN: DPM
Ottowa, Ontario K1A OK2

Commanding Officer
Headquarters, RAAF Base
POINT COOK VIC 3029
Australia

Canadian Army Liaison Office
Bldg 602
Fort Rucker, AL 36362

Netherlands Army Liaison Office
Bldg 602
Fort Rucker, AL 36362

German Army Liaison Office
Bldg 602
Fort Rucker, AL 36362

British Army Liaison Office
Bldg 602
Fort Rucker, AL 36362

French Army Liaison Office
Bldg 602
Fort Rucker, AL 36362

END
DATE
FILMED
5-88
DTIC